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Blood Lead Level Analysis Among Refugee Children Resettled in New Hampshire and Rhode Island

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Abstract

Objective: To examine the association between refugee status and elevated blood lead levels (EBLLs) among children living in two U.S. cities and to assess the effect of the Centers for Disease Control and Prevention recommendations for BLL testing of newly emigrated refugee children for EBLLs.

Design and Sample: A longitudinal study was conducted of 1,007 refugee children and 953 nonrefugee children living, when blood testing occurred, in the same buildings in Manchester, New Hampshire and Providence, Rhode Island.

Measures: Surveillance and blood lead data were collected from both sites, including demographic information, BLLs, sample type, refugee status, and age of housing.

Results: Refugee children living in Manchester were statistically significantly more likely to have an EBLL compared with nonrefugee children even after controlling for potential confounders. We did not find this association in Providence. Compared with before enactment, the mean time of refugee children to fall below 10 μg/dL was significantly shorter after the recommendations to test newly emigrated children were enacted.

Conclusions: Refugee children living in Manchester were significantly more likely to have an EBLL compared with nonrefugee children. And among refugee children, we found a statistically significant difference in the mean days to BLL decline <10 μg/dL before and after recommendations to test newly emigrated children.

Keywords

blood lead; children; recommendations; refugee

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Background

Lead poisoning is a preventable environmental condition. Yet the Centers for Disease Control and Prevention (CDC) estimates that approximately 250,000 children aged 1–5 years are affected (CDC, 2011). The adverse effects of lead in children have been well documented. Exposure to lead can harm a child's renal, nervous, and hematopoietic systems (Agency for Toxic Substances and Disease Registry [ATSDR], 1988; Lidsky & Schneider, 2003) and no safe blood lead level (BLL) in children has been identified. The most highly concentrated source of lead for most children in the United States is lead paint in homes built before 1978 (ATSDR, 1988).

In 2004, CDC issued recommendations for testing the BLL of newly arrived refugee children aged 6 months–16 years (CDC, 2004). The recommendations followed reports in 2001 that stated refugee children who resettled in the United States were at high risk for lead poisoning (Geltman, Brown, & Cochran, 2001). The recommendations also stemmed from the death of a newly emigrated 2-year-old Sudanese girl from lead poisoning in early 2000 (CDC, 2001) and the increased prevalence of elevated blood lead levels (EBLLs) among newly resettled refugee children compared with that of U.S. children (CDC, 2004). As a result, CDC worked with the Office of Global Health Affairs; Office of Refugee Resettlement, and the U.S. Department of State, Bureau of Population, Refugees and Migration to develop a set of guidelines for testing newly emigrated refugee children for lead poisoning. The CDC's recommendations for testing newly emigrated refugee children for lead are:

1. All refugee children between 6 months and 16 years of age have a blood lead test within 90 days of arrival to the United States.
2. A repeat blood lead test of all refugee children 6 months–6 years of age 3–6 months after refugee children are placed in permanent residences, older children if warranted, regardless of initial blood lead test results.
3. Timely and appropriate follow-up of children with EBLLs.

Since 2004, little research has been conducted to evaluate CDC's guidelines on blood lead testing of newly arrived refugee children.

Our study's objectives were to determine whether the CDC recommendations to test and educate newly emigrated refugee children and their families were instrumental in decreasing the prevalence of EBLLs among this population. We compiled data from the New Hampshire Lead Poisoning Prevention Program (NH CLPPP) and the Rhode Island Lead Poisoning Prevention Program (RI CLPPP) for both newly arrived refugee children and nonrefugee children living in the same buildings.

Research Hypotheses

Our goals were to determine whether:

1. Refugee children were more likely to have an elevated BLL,

2. Any differences occurred in the amount of time refugee and nonrefugee children reached BLLs <10 μg/dL, and
3. Recommendations to test newly emigrated children significantly affected the time for BLLs to drop below 10 μg/dL.

Methods

Design and sample

We conducted a longitudinal study to examine the association between refugee status and BLL among children. To assess this association, we examined BLLs of refugee and nonrefugee children living in the same building at the time of the blood lead test. We considered cities for inclusion in this study if they (1) could identify refugee children in the childhood lead poisoning prevention program (CLPPP) surveillance database between 2001 and June 2010, and (2) had protocols for blood lead testing refugee children within 90 days of relocation to the United States and again 60–90 days after their initial blood lead test. Both Manchester, which implemented the recommendation in 2001, and Providence, which implemented the recommendation in 2004, met these criteria. Manchester was home to 639 eligible children; Providence to 368.

We defined a child as anyone <16 years of age in the database with a valid blood lead test and an address of residence in one of the two cities. Nonrefugee children were included in the study if they lived in the same building as a refugee child during the time of the nonrefugee child's blood lead test ($n = 253$ in Manchester, NH and $n = 700$ for Providence, RI) and if they had a blood lead test between January 1995 and June 2010. We collected from the NH and RI CLPPP blood lead surveillance systems, both of which collect laboratory-based reports of blood lead results from across their respective states.

Measures

We obtained demographic information including gender, race, age in months at the time of the blood lead test, sample type of the blood lead test (venous or capillary), and age of housing. To determine age of housing, we examined tax assessor data from Providence and Manchester for a particular address. We then linked housing information to blood lead data to match each child to a particular address. We defined a confirmed EBLL as a child with one venous BLL ≥10 μg/dL or two capillary blood lead tests within 12 weeks, both with a result ≥10 μg/dL. In analyses with more than one blood lead test per child, we used the highest venous confirmed EBLL or second capillary. We coded any unknown blood lead sample type as a capillary sample. The final sample consisted of 1,957 uniquely identified children.

IRB approval was exempted by CDC's Human Subject Matter review because (1) CDC's Healthy Homes and Lead Poisoning Prevention Branch has a cooperative agreement with the two states that collect data, strip all identifiable information, and send the data to CDC on a quarterly basis (and, therefore, all human subject data had been stripped of identifiable information prior to CDC collecting the data for the study—Child and Address IDs were used instead of names and physical addresses) and (2) CDC collects these data from state and local health departments, which thus falls under a blanket approval for CDC's Childhood Blood Lead Surveillance (CBLS) system.

Analytic strategy

We calculated odds ratios (OR) and 95% confidence intervals (95% CI) using generalized estimating equation (GEE); nonrefugee children are not independent from the refugee population in that both groups of children shared a common characteristic—the buildings they lived in (Liang & Zeger, 1986). In addition, a particular child could have been included in the analysis in multiple years if he or she had multiple blood lead tests irrespective of the BLL. Regarding the main effects model, we did not choose only one BLL to represent each child. Instead, we calculated the association between BLL and refugee status of the correlated data with GEE to include as many blood lead tests as possible (Liang & Zeger, 1986). To control for the effect of confounding, demographic variables associated with risk for EBLLs were included in the model to determine whether the association between BLL and refugee status remained statistically significant. We also examined second order associations to determine effect modification between refugee status and a *priori*-selected demographic variables. We created a design variable for age with the categories under 2 years of age, 2 years of age, 3–5 years of age, and 6+ years of age (referent category). The year of the blood lead test was as follows: January 1, 1995–December 31, 2002, January 1, 2003–December 31, 2006, and January 1, 2007–June 2010 (referent). The age of the housing unit was an ordinal variable categorized as pre-1950, 1950–1978, and post-1978 (referent).

We developed Kaplan–Meier survival curves (KM) to determine differences in time-to-decline in BLL before and after recommendations were established. Highest confirmed elevated BLL was treated as a categorical variable in increments of 10 μg/dL. Only children with at least two BLLs—one confirmatory elevated BLL and at least one other test following the elevated BLL—were included in the survival curve. Follow-up stopped at the time when the child's BLL dropped below 10 μg/dL (Kalbfleisch & Prentice, 1980). Children who were followed but who never fell below 10 μg/dL during the study period or who were lost to follow-up were censored at the time of their last blood lead test. Since we found that children did not differ by City, we combined children from Manchester and Providence to give a stronger power for the analysis.

We used the two-tailed Student's *t*-test to examine whether the mean days to BLL dropping below 10 μg/dL before and after recommendations differed between refugee and nonrefugee children. Stratified analyses determined whether these differences remained significant when controlling for initial EBLL.

The Cox Proportional Hazards model identified decline predictors. The predictor variables of interest included:

- City the child was residing in during the blood lead test.
- Age of the child at the time of the blood lead test.
- Year of the blood lead test.
- Gender.

- Time of the year of the blood lead test (summer months vs. Other times of the year).
- Highest confirmed elevated BLL.

Age of housing and sample type were not included in the proportional hazards model. Most children lived in pre-1950 housing units (96%) and had venous sample types (86%). All analyses were done using SAS version 9.2 (2008; SAS Institute Inc., Cary, NC, USA).

Results

Demographic information

There were a total of 1,960 children included in the analysis. Of these, 1,007 were refugee children who had blood lead tests within 90 days of entry into the United States. Refugee children tended to be older, less likely to have a venous blood lead sample, and slightly less likely to have an EBLL in the summer when compared with nonrefugee children living in the same buildings (Table 1). Sixty-three percent of the refugee children lived in Manchester. At the time of their blood lead test, approximately 61% of the total refugee population had at least one venous blood lead test sample, and 22.5% (227) had confirmed elevated BLLs, and 87.5% lived in a pre-1950 housing unit (Table 1). Of the 953 nonrefugee children living in the same buildings as refugee children at the time of the blood lead test, some 54% lived in Providence. Among these nonrefugee children, over 87% had at least one venous blood lead test sample at the time of their blood lead test, 23% had confirmed elevated BLLs, and almost 89% lived in a pre-1950 housing unit (Table 1).

Refugee and nonrefugee children results were similar regarding gender (52% vs. 49% males, respectively). For both Providence and Manchester, however, when compared with the nonrefugee children, a significantly higher proportion of refugee children were older, over 6 years of age ($p < .0001$) and had venous blood lead test samples ($p < .0001$). In addition, refugee children in Providence were more likely than were nonrefugee children to live in pre-1950 housing units (97% vs. 92%, $p = .0002$). Nonrefugee children in Providence were more likely than were refugee children to be identified with elevated BLLs in warm weather months compared with other times of the year ($p = .0002$) (Table 1).

In Providence, a higher proportion of nonrefugee children had EBLLs as compared with refugee children, while in Manchester the reverse was the case—refugee children were twice as likely to have an EBLL as compared with nonrefugee children (Table 2).

Refugee status and elevated blood lead level

To determine whether the association between refugee status and EBLL remained statistically significant in Manchester even after controlling for potential confounders, we calculated the adjusted odds ratio. The evidence suggested that even after controlling demographic risk factors, refugee children living in Manchester continued to be twice as likely to have an EBLL compared with nonrefugee children, $OR = 2.09$, 95% $CI = 1.18–3.69$ (Table 2). In Providence, however, the association remained insignificant, $OR = 1.23$, 95% $CI = .87–1.75$ (Table 2).

Time to blood lead level decline below 10 μg/dL.

Figure 1 describes the KM curves for children stratified by refugee status before and after recommendations to test newly emigrated children. The location of the curves at each successive 250-day increment after entry signifies the percentage of each cohort still elevated. While the rates of decline before and after the recommendations were similar for refugee and nonrefugee children, the figure also shows statistically significant differences in the mean days-to-decline among refugee children (Table 4). While an overall decrease occurred in the mean days-to-decline for nonrefugee children before and after recommendations—792 days to 507 days—a near 50% decrease occurred in the number of days-to-decline among refugee children—889 days to 471 days—and this decrease was statistically significant, $p = .0001$ (Table 3).

Predictors of blood lead level decline.

Results from Cox Proportional Hazards Model suggest that the year of confirmed EBLL was significantly associated with time to when a child's BLL dropped below <10 μg/dL (Table 4). We found that the BLLs of children who were identified and confirmed with EBLL before the recommendations were established, between 1995 and 2002, took significantly longer to decline below 10 μg/dL compared with children who were identified and confirmed with EBLL after the recommendations were in place (2003–2010) (Table 4). This association remained regardless of refugee status For example, children who were identified and confirmed with EBLL before the recommendations were in place, between 1995 and 2002, took twice as long to decline less than 10 μg/dL compared with children identified and confirmed soon after recommendations were in place (2003–2006) (hazard ratio [HR] = 1.80, $p = .021$). The decline was six times faster among children identified and confirmed with EBLL between 2007 and 2010 compared with those identified and confirmed before recommendations were in place (HR = 5.86, $p < .0001$) (Table 4). In addition, compared with children older than 6 years of age, the BLL of children <2 years of age took significantly longer to decline (HR = .56, $p = .030$) (Table 4). Regarding the rate of decline based on initial blood lead levels, children whose initial BLL was 15–19 μg/dL declined significantly slower compared to children with an initial EBLL between 10 and 14 μg/dL (HR = .47 $p = .001$) (Table 4). Similar results were found for children with an initial EBLL greater than that of 20 μg/dL (Table 4).

Discussion

Refugee children in Manchester were more likely to have an elevated BLL compared with nonrefugee children. This was not true in Providence (Table 2) where the proportion of nonrefugee children with a confirmed EBLL was higher than refugee children, though it was not statistically significant. One reason for this outcome could have been risk factors among nonrefugee children in Providence that would have made them more likely to have an EBLL, for example, race/ethnicity, exposure to dust lead, and condition of the house during the time of the blood lead test were not collected in this study. Another possible reason for more EBLLs in Manchester refugee children was the high number of capillary tests compared with nonrefugee children. Capillary tests have a much higher risk of contamination. Follow-up testing is required if a child has an elevated capillary blood lead test, but a second capillary can confirm it, a venous test is not required. While this factor is controlled for in Table 2, there was a large difference in the number of refugee children in Manchester receiving a capillary test compared to Providence. And lastly, over 60% of the nonrefugee children in Providence had their blood lead test between 1995 and 2002, compared with only 13% nonrefugee children in Manchester. This was the time before CDC recommended primary prevention as a way to reduce EBLLs in children. After the switch from secondary to primary prevention, the country, as a whole, saw a temporal trend to lower numbers of EBLLs. Therefore, the number of children with EBLLs was much higher compared to the later years in the study. We were not able to remove these children from the analysis due to a reduction in power that would have made the analysis less precise.

For over 50 years, deteriorated lead-based paint from older homes has been the most frequent high-dose lead source for children with EBLLs (Pirkle et al., 1994). While age-related risk is well documented in U.S. children (Brody et al., 1994), it does not predict risk for refugee children (Geltman et al., 2001).

As expected, we found that the length of time for refugee children's BLLs to drop below 10 μg/dL depended on the time of the blood lead test (i.e., before or after recommendations were established for refugee children). To our knowledge, no one has tested the effectiveness of these CDC recommendations regarding refugee children. In 2004, CDC's Lead Poisoning Prevention The New Hampshire case study demonstrated that although some children had EBLLs when they arrived in the United States, the majority of the children did not, which proved to be important data on which to establish the need for a second blood lead test (Kellenberg et al., 2005).

Refugee children appeared to be followed more closely after recommendations were established and their EBLLs decreased significantly faster (mean time: 889 days to 471 days, 47% reduction in time, $p = .01$). The time-to-decline to less than 10 μg/dL was appreciably shorter after the recommendations were in place. While there was an overall decrease in the mean days-to-decline for nonrefugee children before and after recommendations (793–507 days, 36% reduction in time, $p = .05$), the refugee children declined at an even faster rate (889–471 days).

An examination of the difference in mean days-to-decline among nonrefugee children before and after the recommendations became effective reflected other changes to screening, case management, and reporting laws. In the early 1990s, CDC recommended universal screening. In 1997, CDC released a new document that recommended targeted screening to high risk children. Over the course of the study years, NH and RI each lowered their levels for initiating case management and reporting laws from laboratories to send all blood lead test, not just elevated ones, also played a role. The refugee children with EBLLs are dropping to below 10 μg/dL faster now than before the recommendations' effect. The public health importance of this recommendation and the effect it has had is important—not only in preventing EBLLs, but also in identifying those in need of care.

A limitation of this study was an inability to control for other important demographic risk factors. These factors, including for example race, may have influenced BLL time-to-decline to fewer than 10 μg/dL. In addition, we did not have medical information on children with high BLLs or whether chelation therapy was administered, which may have influenced their time-to-decline. There were seven children in the survival analysis with EBLL's over 45 μg/dL who would have been eligible for chelation therapy. We did not have measures of iron status for most of the refugee children, which may have affected both their risk of developing an EBLL as well the time-to-decline to less than 10 μg/dL.

Our analysis was also limited by an inability to calculate the exact time-to-decline to fewer than 10 μg/dL. We did not know precisely when BLLs declined to less 10 μg/dL. We only knew when the children were tested and when their BLLs fell below 10 μg/dL and had to estimate time to the event. As a result, 37.6% of refugee and nonrefugee children were censored before their BLLs fell below 10 μg/dL, suggesting that many of the children with EBLLs may have been lost to follow-up. Also, we do not have information on how long these children were living in the addressing before their blood lead test. This could influence the EBLL as well as the time-to-decline.

Lastly, a potential study limitation could be a misclassification of refugee status before the CDC recommendations became effective. Both CLPPPs match their blood lead data with the Refugee Resettlement Agency on a regular basis, including linking older data. Looking at potential misclassified refugee children (coded as nonrefugee children), using last name as a proxy, showed an additional 12 confirmed EBLLs and 56 children with lower BLLs. The change in odds ratio showed a bias toward the null (*OR* = 1.08–.99). Given this potential misclassification, we believe the odds of refugee child having an EBLL may be less than what we have reported.

This study of 1,007 refugee children and 953 nonrefugee children living at the same addresses adds significant information to the body of literature examining the CDC recommendations for refugee children entering the United States and having timely blood lead tests and follow-up the CDC recommendations also incorporate early postarrival evaluation and therapy. These procedures include a nutritional evaluation for the child's iron status to include a hemoglobin/hematocrit and one or more of the following: mean corpuscular volume combined with red cell distribution, ferritin, transferring saturation, or reticulocyte hemoglobin content. Other studies have found a connection between iron levels, race, and EBLLs regardless of refugee status (Raymond, Anderson, Feingold, Homa, & Brown, 2009).

Refugee children are eligible for Medicaid for at least 8 months after arrival in the United States. Blood lead testing complies with Medicaid's Early and Periodic Screening, Diagnosis, and Treatment requirements for clinical care of young children. Our findings highlight the importance of this policy as well as CDC's recommendations for testing and follow-up of refugee children. We therefore recommend:

- Continued blood lead testing as part of the medical screening of all newly arrived refugee children. In that way appropriate medical, educational, and environmental management may be initiated promptly.
- Continued evaluation of possible new nontraditional exposure sources to lead.

- Continued timely follow-up testing of confirmed cases of EBLL.

Refugee children under 2 years of age are more at risk for having an elevated BLL than are nonrefugee children at least 6 years of age. Since the recommendations for testing refugee children for lead have been in place, time-to-decline has been reduced by more than 1 year. In addition, blood lead levels for refugee and nonrefugee children with elevated BLLs have declined at the same rate. The CDC recommendations appear to have helped establish guidelines for testing refugee children in a timely manner and to have helped establish guidelines for follow-up testing that have proved important (Caron et al., 2001). Testing of refugee children upon arrival into the United States should continue. Follow-up testing of those with confirmed EBLL is also strongly encouraged.

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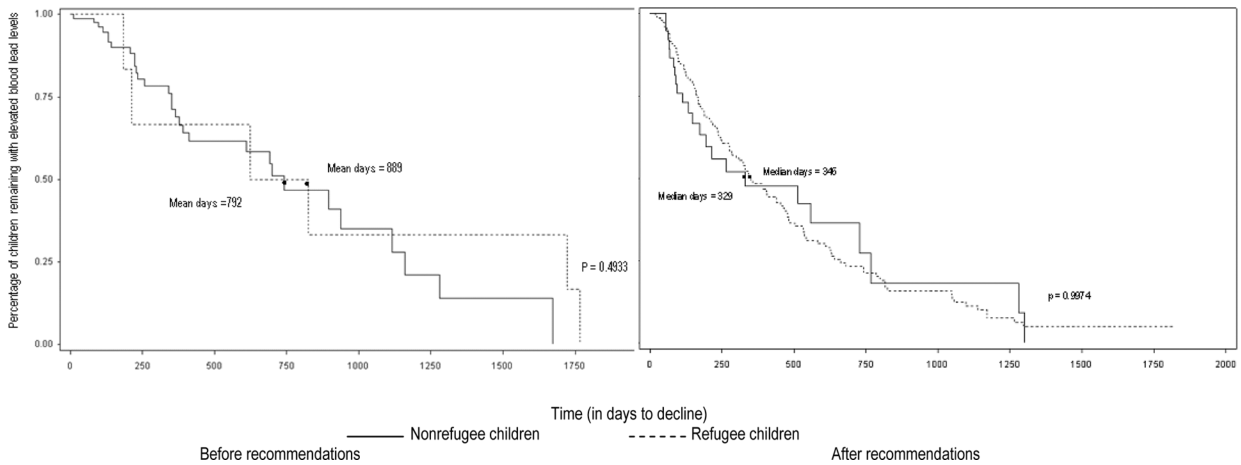

Figure.

Kaplan-Meier curves of the time required for blood lead levels to drop below 10 µg/dL before and after recommendations were established, stratified on refugee status, of children in Manchester, NH and Providence, RI

TABLE 1.

Comparison of Refugee and Nonrefugee Children Manchester, NH and Providence, RI: Blood Lead Variables and Selected Demographic Characteristics

	Manchester, NH					Providence, RI				
Characteristics	Refugees		Nonrefugees		Chi-square	Refugees		Nonrefugees		Chi-square
	n	%	n	%	p-value	n	%	n	%	p-value
Gender										
Male	332	*52.2*	126	*49.8*	*0.5187*	195	*53.0*	345	*49.3*	0.2502
Female	304	*47.8*	127	*50.2*		173	*47.0*	355	*50.7*	
Age										
< 2 years	263	*14.7*	195	*48.0*	*<0.0001*	105	*11.4*	351	*28.9*	<0.0001
2 years	240	*13.4*	91	*22.4*		108	*11.8*	234	*19.3*	
3 – 5 years	583	*32.5*	100	*24.6*		325	*35.4*	503	*41.4*	
6+ years	707	*38.4*	20	*4.9*		381	*41.4*	127	*10.5*	
Sample Type										
Capillary	1040	*58.0*	121	*29.8*	*<0.0001*	11	*1.2*	96	*7.9*	<0.0001
Venous	753	*42.0*	285	*70.2*		908	*98.8*	1119	*92.1*	
Seasonality										
EBLL summer	492	*27.4*	100	*24.6*	*0.2492*	199	*21.7*	350	*28.8*	0.0002
EBLL other times	1301	*72.6*	306	*75.4*		720	*78.3*	865	*71.2*	
Blood Lead Levels										
< 5 μg/dL	252	*39.5*	105	*41.5*	*0.0503*	120	*33.1*	232	*33.1*	*0.4927*
5 – < 10 μg/dL	245	*38.3*	114	*45.1*		163	*36.9*	279	*39.9*	
≥ 10 μg/dL	142	*22.2*	34	*13.4*		85	*30.0*	189	*27.0*	
Age of Housing										
Pre-1950	841	*82.2*	222	*80.4*	*0.4976*	612	*96.7*	758	*92.1*	0.0002
1950 - present	182	*17.8*	54	*19.6*		21	*3.3*	65	*7.9*	
Number of Tests										
1995 – 2002	69	*3.9*	53	*13.1*	*0.0067*	47	*5.1*	766	*63.1*	<0.0001
2003 – 2006	1085	*60.5*	136	*33.5*		422	*45.9*	271	*22.3*	
2007 – 2010	639	*35.6*	217	*53.4*		450	*49*	178	*14.6*	

Chi-square statistic.

p≤0.05 statistically significant

*There were three refugee children with missing gender who were not counted in gender.

TABLE 2.

Univariate and Multivariate Full Model Analyses for the Odds Ratio of a Refugee Child Having a Blood Lead Level ≥10 μg/dL, Controlling for Age at the Time of the Test, Sample Type, Age of Housing, Seasonality, and Gender in Manchester and Providence

	Model 1 *Univariate Analysis*				Model 2 *Multivariate Logistic Regression Model with Manchester, NH subset*				Model 2 *Multivariate Logistic Regression Model with Providence, RI subset*			
Variable	**Parameter Estimate**	**OR**	**95% CI**	**p-value (chi-sq)**	**Parameter Estimate**	**OR**	**95% CI**	**p-value (chi-sq)**	**Parameter Estimate**	**OR**	**95% CI**	**p-value (chi-sq)**
Refugees[a] in Manchester, NH	0.612	1.84	(1.23–2.76)	0.003	0.737	2.09	(1.18–3.69)	0.011				
Refugees[a] in Providence, RI	0.198	1.22	(0.92–1.62)	0.172					0.209	1.23	(0.87–1.75)	0.240
Age at time of BL test[b]												
3–5 year olds					1.176	3.24	(1.85–5.69)	<0.0001	0.249	1.28	(0.90–1.83)	0.167
2 year olds					1.014	2.76	(1.32–5.75)	0.007	0.216	1.24	(0.78–1.96)	0.355
< 2 year olds					1.156	3.18	(1.48–6.81)	0.003	0.186	1.20	(0.78–1.86)	0.402
Gender[c]					−0.355	0.70	(0.46–1.06)	0.093	0.320	1.38	(1.04–1.83	0.027
Sample Type[d]					1.449	4.26	(2.71–6.82)	<0.0001	0.932	2.54	(1.10–5.86)	0.029
Age of Housing[e]												
Pre-1950					1.930	6.89	(0.84–56.48)	0.072	−0.699	0.50	(0.22–1.13)	0.095
1950–1978					1.788	5.98	(0.66–54.49)	0.113	-	-	-	-
Summer BL tests[f]					0.385	1.47	(1.01–2.14)	0.044	0.185	1.20	(0.98–1.48)	0.081

a - referent = non-refugee

b - referent = 6+ years old

c - referent = female

d - referent = Capillary

e - referent = Post 1978

f - referent = non-Summer months

^ - Regression with significance at p<0.05 for BLL≥10 μg/dL

*GEE Analysis with significance at $p<0.05$

TABLE 3.

Unadjusted Median Days and 95% CI of the Time Required for BLLs to Drop Below 10 μg/dL in Manchester and Providence (Combined)

Variable	Number	Median Days to decline	95% CI
Refugee	157	357	(283, 467)
Nonrefugee	122	691	(378, 896)
Age at Confirmed EBLL			
<2 years	83	663	(346, 767)
2 years	44	641	(216, 938)
3–5 years	114	378	(325, 477)
6+ years	38	394	(340, 483)
Entry EBLL			
10–14 μg/dL	158	352	(286, 454)
15–19 μg/dL	61	680	(406, 1169)
20+ μg/dL	60	799	(512, 1047)
Year of confirmed EBLL			
1995–2002	95	504	(403, 611)
2003–2006	144	440	(329, 531)
2007–2010	40	131	(94, 175)

TABLE 4.

Cox Univariate and Multivariate Hazard Analyses for the Time to Decline Below 10 ug/dL, Controlling for Age at Confirmed EBLL, Sample Type, Age of Housing, City, and Gender in Manchester and Providence

Variable	Parameter Estimate	p-value	HR	95% CI
Refugee[a]	0.392	0.018	1.48	(1.071, 2.048)

Variable	Parameter Estimate	p-value	HR	95% CI
Refugee[a]	−0.301	0.184	0.74	(0.475, 1.154)
City[b]	0.144	0.421	1.16	(0.813, 1.641)
Age at Confirmed EBLL[c]				
3–5 years	−0.090	0.711	0.91	(0.567, 1.471)
2 years	−0.392	0.189	0.68	(0.377, 1.212)
< 2 years	−0.579	0.030	0.56	(0.332, 0.946)
Entry EBLL[d]				
15–19 µg/dL	−0.747	0.001	0.47	(0.304, 0.740)
20+ µg/dL	−0.926	<0.0001	0.40	(0.257, 0.611)
Year of Confirmed EBLL[e]				
2003–2006	0.585	0.021	1.80	(1.093, 2.949)
2007–2010	1.768	<0.0001	5.86	(3.249, 10.559)
Gender[f]	0.075	0.468	1.08	(0.880, 1.320)
Summer confirmed EBLL[g]	0.360	0.041	1.43	(1.014, 2.027)

[a] - referent = nonrefugee

[b] - referent = Providence, RI

[c] - referent = 6+ years old

[d] - referent = 10–14 µg/dL

[e] - referent = 1995 – 2002

[f] - referent = female

[g] - referent = non-summer months

GEE analysis with significance at $p<0.05$